

AMENDMENTS TO THE CLAIMS:

This listing of claims will replace all prior versions, and listings, of claims in the application:

LISTING OF CLAIMS:

1. (Currently Amended) A plasma processing system comprising:
 - a plasma processing chamber;
 - a vacuum pump connected to the processing chamber;
 - a substrate support on which a substrate is processed within the processing chamber;
 - a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;
 - a gas injector extending through the dielectric member, the gas injector comprising a body including an axial end surface exposed within the processing chamber, a side surface extending axially from the axial end surface, and a plurality of gas outlets including at least one on-axis outlet in the axial end surface and a plurality of spaced-apart off-axis outlets in the side surface, the off-axis outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate;
 - a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet;

flow controllers operable to supply process gas from the common gas supply at flow rates that are independently varied between the on-axis outlet and the off-axis outlets into the processing chamber; and
an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

2. (Original) The system of Claim 1, wherein the system is a high density plasma chemical vapor deposition system or a high density plasma etching system.

3. (Original) The system of Claim 1, wherein the RF energy source comprises an RF antenna and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.

4. (Previously Presented) The system of Claim 1, wherein the first gas line is in fluid communication with an axially extending central bore in the injector body, and the second gas line is in fluid communication with an annular gas passage surrounding the central bore.

5. (Previously Presented) The system of Claim 1, wherein the injector body is cylindrical shaped and the off-axis outlets are circumferentially spaced apart.

6. (Original) The system of Claim 1, wherein the gas injector injects the process gas at a subsonic, sonic, or supersonic velocity.

7. (Currently Amended) A plasma processing system comprising:

- a plasma processing chamber;
- a vacuum pump connected to the processing chamber;
- a substrate support on which a substrate is processed within the processing chamber;
- a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;
- a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including a planar axial end face having an on-axis outlet therein and a conical side surface having off-axis outlets therein, the on-axis outlet receiving process gas from a central passage in the injector and the off-axis outlets receiving process gas from an annular passage surrounding the central passage, the gas injector supplying process gas at flow rates that are independently varied between ~~at least some of the outlets including the on-axis outlet and the off-axis outlets~~ into the processing chamber;
- a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and
- an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

8. (Currently Amended) The system of Claim 1, wherein the gas injector is removably mounted in the dielectric window member and supplies the process gas into a central region of the chamber.

9. (Currently Amended) A plasma processing system comprising:
a plasma processing chamber;
a vacuum pump connected to the processing chamber;
a substrate support on which a substrate is processed within the processing chamber;
a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;
a gas injector extending through the dielectric member such that a distal end of the gas injector is exposed within the processing chamber, the gas injector including at least one on-axis outlet which injects process gas in an axial direction perpendicular to a plane parallel to an exposed surface of the substrate and off-axis gas outlets which inject process gas at an acute angle relative to the plane parallel to the exposed surface of the substrate, the off-axis outlets being circumferentially spaced apart from each other, the gas injector supplying process gas at flow rates that are independently varied between ~~at least some of the~~ on-axis outlet and the off-axis outlets into the processing chamber;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

10. (Currently Amended) A plasma processing system comprising:
 - a plasma processing chamber;
 - a vacuum pump connected to the processing chamber;
 - a substrate support on which a substrate is processed within the processing chamber;
 - a dielectric member having an interior surface facing the substrate support, wherein the dielectric member forms a wall of the processing chamber;
 - a gas injector removably mounted in an opening in the dielectric member and extending through the dielectric member such that a single distal end of the gas injector is exposed within the processing chamber, a vacuum seal being provided between the gas injector and the dielectric window member, the gas injector including a plurality of gas outlets in the single distal end which are each located below the interior surface of the dielectric member, the gas outlets including at least one on-axis outlet and a plurality of off-axis outlets, the off-axis outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate, the gas outlets supplying process gas at flow rates that are independently varied between ~~at least some of the~~ on-axis outlet and the off-axis outlets into the processing chamber;
 - a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the on-axis outlet

but not with the off-axis outlets and the second gas line being in fluid communication with the off-axis outlets but not with the on-axis outlet; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

11. (Original) The system of Claim 1, wherein the RF energy source comprises an RF antenna in the form of a planar or non-planar spiral coil and the gas injector injects the process gas toward a primary plasma generation zone in the chamber.

12. (Cancelled)

13. (Original) The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using variable flow restriction devices.

14. (Original) The system of Claim 1, wherein the ratio of gas flow through at least some of the gas outlets is independently varied using a network of valves and throttling elements.

15. (Original) The system of Claim 1, wherein the gas injector is further provided with an electrically conducting shield which minimizes plasma ignition within gas passages located in the gas injector.

16-38. (Canceled)

39. (Previously Presented) The system of Claim 1, wherein the on-axis outlet and the off-axis outlets are oriented at different angles relative to an exposed surface of the substrate.

40. (Previously Presented) The system of Claim 10, wherein the plurality of gas outlets in the single distal end of the gas injector are oriented at different angles relative to an exposed surface of the substrate.

41. (Currently Amended) A plasma processing system, comprising:
a plasma processing chamber;
a vacuum pump connected to the processing chamber;
a substrate support on which a substrate is supported within the processing chamber;
a dielectric member having an interior surface facing the substrate support, the dielectric member forming a wall of the processing chamber;
a gas injector body extending through the dielectric member such that a distal end of the gas injector body is exposed within the processing chamber, the gas injector body including a plurality of gas outlets which are disposed within the processing chamber below the interior surface of the dielectric member, the gas outlets including at least one on-axis outlet and a plurality of off-axis outlets which

inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate;

a common gas supply in fluid communication with a first gas line and a second gas line, the first gas line being in fluid communication with the at least one first on-axis outlet but not with the second off-axis outlets and the second gas line being in fluid communication with the second off-axis outlets but not with the first on-axis outlet;

flow controllers providing independently adjustable flow rates of process gas between ~~at least some of the on-axis outlet and the off-axis outlets~~ into the processing chamber; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

42. (Currently Amended) A plasma processing system comprising:

a plasma processing chamber;

a vacuum pump connected to the processing chamber;

a substrate support on which a substrate is processed within the processing chamber;

a dielectric member having an interior surface facing the substrate support, the dielectric member forming a wall of the processing chamber;

a gas injector comprising an injector body including at least first and second gas inlets, at least first and second gas passages, an axial end surface, a side surface extending from the axial end surface toward the interior surface of the

dielectric member, and at least a first gas outlet in the axial end surface and a plurality of second gas outlets in the side surface at locations between the axial end surface and the interior surface of the dielectric member, the second gas outlets inject process gas at an acute angle relative to a plane parallel to an exposed surface of the substrate, the first gas passage being in fluid communication with the first inlet and first outlet, and the second gas passage being in fluid communication with the second inlet and second outlet, the first and second gas passages not being in fluid communication with each other;

a common gas supply in fluid communication with the first gas passage and the second gas passage;

flow controllers providing independently adjustable flow rates of gas through the first and second outlets; and

an RF energy source which inductively couples RF energy through the dielectric member and into the chamber to energize the process gas into a plasma state to process the substrate.

43. (Previously Presented) The system of Claim 1, wherein the system is a plasma etching system.

44. (Previously Presented) The system of Claim 7, wherein the system is a plasma etching system.

45. (Previously Presented) The system of Claim 9, wherein the system is a plasma etching system.

46. (Previously Presented) The system of Claim 10, wherein the system is a plasma etching system.

47. (Previously Presented) The system of Claim 41, wherein the system is a plasma etching system.

48. (Previously Presented) The system of Claim 42, wherein the system is a plasma etching system.

49. (Previously Presented) The system of Claim 9, wherein the off-axis outlets are circumferentially spaced apart from each other by 120°, 90° or 45°.

50. (Previously Presented) The system of Claim 1, wherein the common gas supply comprises a single third gas line in fluid communication with the first gas line and the second gas line.

51. (Currently Amended) The system of Claim 1, wherein each of the on-axis and the off-axis outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough and the common gas supply is a gas mixture.

52. (Currently Amended) The system of Claim 7, wherein each of the on-axis and the off-axis outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough and the common gas supply is a gas mixture.

53. (Currently Amended) The system of Claim 9, wherein each of the gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough and the common gas supply is a gas mixture.

54. (Currently Amended) The system of Claim 41, wherein each of the gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough and the common gas supply is a gas mixture.

55. (Currently Amended) The system of Claim 42, wherein each of the first and second gas outlets includes an interior orifice contoured to provide sonic or supersonic flow therethrough and the common gas supply is a gas mixture.

56. (Previously Presented) The system of Claim 1, wherein at least one of the on-axis and the off-axis outlets has a uniform diameter along the entire length thereof.

57. (Previously Presented) The system of Claim 7, wherein at least one of the on-axis and the off-axis outlets has a uniform diameter along the entire length thereof.

58. (Currently Amended) The system of Claim 9, wherein ~~at least one of the gas outlets has a uniform diameter along the entire length thereof~~ the on-axis and off-axis outlets are in a planar axial end face of the gas injector.

59. (Previously Presented) The system of Claim 10, wherein at least one of the gas outlets has a uniform diameter along the entire length thereof.

60. (Previously Presented) The system of Claim 41, wherein at least one of the gas outlets has a uniform diameter along the entire length thereof.

61. (Previously Presented) The system of Claim 42, wherein at least one of the first and second gas outlets has a uniform diameter along the entire length thereof.